(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 October 2001 (25.10.2001)

PCT

(10) International Publication Number
WO 01/79703 A1

(51) International Patent Classification[7]: F04D 15/00

(21) International Application Number: PCT/CA01/00541

(22) International Filing Date: 12 April 2001 (12.04.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/197,069 13 April 2000 (13.04.2000) US
60/242,619 23 October 2000 (23.10.2000) US

(71) Applicant *(for all designated States except US)*: TESMA INTERNATIONAL INC. [CA/CA]; 99 Ortona Court, Concord, Ontario L4K 3M3 (CA).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: PASCOE, David, Mark [CA/CA]; 486 Hewitt Circle, Newmarket, Ontario L3X 2H1 (CA).

(74) Agent: IMAI, Jeffrey, T.; Magna International Inc., 337 Magna Drive, Aurora, Ontario L4G 7K1 (CA).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European

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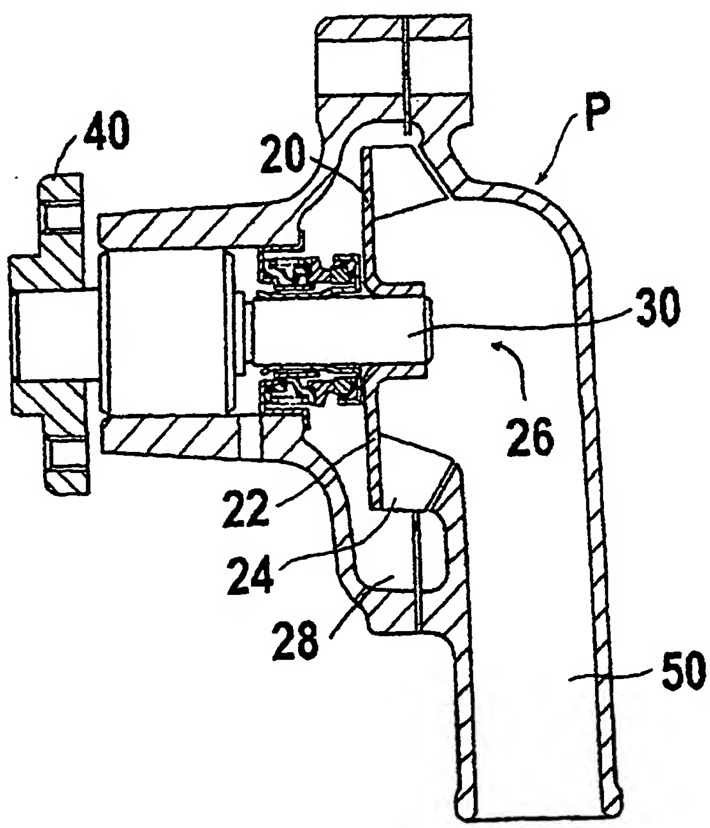
(54) Title: VARIABLE FLOW WATER PUMP



(57) Abstract: A variable-capacity water pump includes a housing having an impeller mounted on a rotatable shaft. The impeller includes a plurality of vanes pivotally coupled between upper and lower shroud and operatively coupled to a pitch plate. As the pump speed increases in response to increasing engine speed, the pitch plate controls the rotation of the impeller vanes about a fixed rivet from a maximum pitch position, toward a minimum pitch position, thereby lowering pump output according to engine cooling requirements.

WO 01/79703 A1

patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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VARIABLE FLOW WATER PUMP

Field of the Invention

The subject invention relates to a variable capacity water pump with an impeller for use in automotive engines and the like.

Description of the Related Art

The cooling mechanism for an internal combustion engine used in an automobile normally comprises a coolant pump, commonly referred to as a water pump, of a centrifugal-type. The most common arrangement utilizes the engine rotation to drive a shaft via a belt connection between a driving pulley (connected to the crankshaft) and a driven pulley. The example shown in Figure 1 shows a typical water pump P with an impeller 20 fastened to a rotating shaft 30 and drivable by the pulley 40, which is attached to the engine crankshaft (not shown). The impeller 20 includes a flange 22 having several integral blades or vanes 24 projecting axially therefrom toward the inlet path 26. When the pulley 40 rotates, the drive shaft 30 rotates, and thus, the vanes 24 similarly rotate with the impeller 20. Coolant enters the passageway 50 and is thrown outward by centrifugal force to an outlet port (not shown) via the outlet path 28.

Although this system is simple, it has the disadvantage of supplying a fixed capacity of coolant that is often unnecessarily large. This over-capacity arises because the pump output is sized to deliver a minimum flow amount of coolant at low engine speeds. At higher engine speeds, such as those experienced under normal highway driving conditions, the flow amount becomes excessive because it is directly proportional to engine speed. This leads to poor cooling efficiencies and increased power losses.

An alternative arrangement uses an electric motor instead of the engine to drive the impeller. For instance, US Patent No. 3,840,309 discloses a variable capacity centrifugal pump with vanes that move via a pivoting linkage mechanism between a threaded nut and a cross-mount that is attached to a propeller shaft rotated by an electric motor. However, this type of design adds weight and cost because extra components are

required. Also, the capacity of the battery and generator needs to be increased in order to supply the extra power needed by the motor.

Still further, US Patent Nos. 4,752,183 and 5,169,286 disclose two similar variations of a variable output centrifugal pump utilizing a shroud with recesses through which the vanes protrude. The shroud is axially moved over the vanes to vary the exposed area and, therefore, the quantity of coolant that flows through the water pump. This design fails to properly control fluid flow into the volute and allows coolant to pass beneath the impeller. Furthermore, it does not allow for varying the pump capacity with the engine rotational speed.

Summary Of The Invention

The present invention provides a water pump having variable capacity in accordance with a relatively simple mechanical means that obviates the need for expensive electric motors or shrouds that can cause turbulent flow.

According to the present invention, a variable capacity coolant pump includes a pump body for directing the flow of fluid through the pump between an inlet and an outlet and a shaft rotatably connected to the pump body. An impeller is coupled to the pump body for pumping fluid through the pump body from the inlet to the outlet. The impeller includes a shroud and at least one vane pivotally coupled to the shroud for pivotal movement between a plurality of pitch angles relative to the shaft. A pitch plate is operatively coupled to the vane for controlling the pitch angle of the vane. A spring is coupled to the pitch plate for biasing the vane to a maximum pitch angle wherein the vane varies in pitch in response to a force of fluid pressure from the inlet and automatically reduces the pitch angle of the vane upon an increase in the fluid pressure from the inlet to reduce the flow of fluid to the outlet. In an alternative embodiment, the pitch angle is also controlled externally via an actuator.

Brief Description Of The Drawings

Advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a cross-sectional view of a prior art water pump;

Figure 2 is a cross-sectional view of a water pump of one embodiment according to the present invention;

Figure 3 is a top view of a pitch plate of the water pump according to Figure 2;

Figure 4 is a perspective view of an impeller vane and pitch control tab of the water pump according to Figure 2;

Figure 5a is a partial section view of a water pump according to Figure 2 showing the location of the vanes in the highest pitch position;

Figure 5b is a partial section view of a water pump according to Figure 2 showing the location of the vanes in the lowest pitch position;

Figure 6 is a cross-sectional view of a water pump of a second embodiment according to the present invention;

Figure 7 is a top view of the pitch plate of the water pump according to Figure 6;

Figure 8 is a perspective view of the impeller vane and pitch control tab of the water pump according to Figure 6;

Figure 9a is a partial section view of a water pump according to Figure 6 showing the location of the vanes in the highest pitch position;

Figure 9b is a partial section view of a water pump according to Figure 6, and showing the location of the vanes in the lowest pitch position;

Figure 10 is a partial cross-sectional view of a water pump of a third embodiment according to the present invention;

Figure 11 is a cross sectional view of a water pump of a fourth embodiment according to the present invention;

Figure 12 is a partial section of the water pump according to Figure 11, showing details of the internal moving parts; and

Figure 13 is a perspective view of the pitch plate of Figure 11.

Detailed Description Of The Preferred Embodiment

Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, Figure 2 shows a first preferred embodiment of a variable capacity coolant pump, or water pump P comprised of a housing 4 including an impeller I. The impeller I is fastened to a rotatable shaft 10 drivable by a pulley (not shown) that is belt driven from the engine crankshaft in a well-known manner.

The impeller I includes a lower flange or shroud 5 having a plurality of pivotal vanes 2 projecting axially toward the inlet path of the pump. Each vane 2 is connected to an upper flange or shroud 1 via rivets 11 and guided within arcuate shaped slots 3a, 3b between the shrouds 1, 5. Directly underneath the lower shroud 5, and rigidly connected to the rotatable shaft 10, is a pitch plate 6 having slots 13 to accommodate the pitch control tabs 12 projecting from the bottom of each of the plurality of vanes 2, as best shown in Figures 3 and 4.

Further, a torsional pitch spring 7 is disposed around the rotatable shaft 10, and extends to the edge of the lower shroud 5, such that the torsional spring 7 normally biases the impeller I to its most forward position, where the vanes 2 are held in their highest pitch position. The slots 13 in the pitch plate 6 restrict the movement of the vanes so that they are set to an optimal position, or pitch, for low pump rotational speeds.

In operation, when the engine is first started, the torsional pitch spring 7 holds the impeller in its most forward position. The vanes 2 rotate about their rivets 11 and are held in their highest pitch position, as shown in Figure 5a. The highest pitch position may be further defined by the vanes 2 extending generally transverse or approaching perpendicular to the center axis of the shroud 1. As the pump speed increases, the drag torque on the impeller I increases, causing the impeller I to rotate in a reverse direction relative to the pitch plate 6. This movement of the impeller I relative to the pitch plate 6 causes the vanes 2 to rotate about their rivets 11 to a lower pitch position, as shown in Figure 5b. The lower pitch position may be further defined by the vanes arranged generally parallel with the circumferential outer edge of the shroud 1. A force balance is realized between the torsional pitch spring 7, which biases the impeller I to its forward most position (and vanes 2 in the highest pitch position), and the fluid drag torque, which biases the impeller I to its rearward position (and vanes 2 in the lowest pitch position).

Therefore, as the pump speed increases in response to increasing engine speed,

the vanes 2 rotate about their rivets 11 from their highest pitch position, illustrated in Figure 5a, toward their lowest pitch position, illustrated in Figure 5b. The guiding slots 13 that are cut into the pitch plate 6 limit the maximum position, or range of movement, of the vanes 2 to a predetermined limit, dependent on engine cooling requirements.

Referring now to Figures 6-9, another embodiment of the impeller arrangement is illustrated. The essential elements are arranged in a similar fashion as before, except that the pitch plate 106 is axially fixed to the rotational shaft 110, but is rotationally free thereon and is affected by the torsion pitch spring 107, which no longer contacts the lower shroud 105. Further, the pitch control tabs 112 are now located on the outer edges of the vanes 102, and the rivets 111 are located on the opposite edge, as shown in Figures 6 and 8.

At low rotational speeds, the torsion pitch spring 107 holds the vanes 102 in their outer most, or highest pitch, position, shown in Figure 9a. The torsional pitch spring 107 reacts against the rotational shaft 110 and rotates the pitch plate 106 against the pitch control tabs 112 on the bottom of the vanes 102. As the pump rotational speed increases, the fluid pressure on the vanes 102 causes the vanes 102 to rotate about their rivets 111 against the pressure being applied to the pitch control tabs 112 by the pitch plate 106. A balance of forces is once again achieved, where the force exerted by the torsional pitch spring 107 onto the vanes 102 is opposed by the back pressure of the fluid flowing across the forward face of the vanes 102. At high rotational speeds, the vanes 102 are rotated to their lowest pitch positions, illustrated in Figure 9b.

Figure 10 discloses an alternate embodiment whereby the torsional pitch spring is replaced by a compression pitch spring 113, a sliding shell 114, a helically motivated rotating shell 115 and a C-clip 116. The sliding shell 114 is rotationally fixed onto the main rotational shaft 110 by the spline 117, and the rotating shell 115 is axially fixed by the C-clip 116. Tabs 119 on the sliding shell 114 consequently impart a rotating torque onto the rotating shell 115 by applying an axial force to a helical slot 120 in the rotating shell 115. The combination of compression pitch spring 113, sliding shell 114, rotating shell 115 and the straight spline 117 applies the same outward force to the vanes 102 by imparting a rotating force onto the pitch plate 106. This applies an outward force to the pitch control tab 112 located on the bottom of the vane 102. The rotating force is

generated when the compression pitch spring 113 axially pushes the sliding shell 114 against the rotating shell 115. The outward force on the vanes 102, derived from the compression spring 113, is again balanced by the fluid pressure acting on the vanes.

Finally, Figures 11-13 illustrate yet another alternate embodiment of the invention whereby the vane pitch is controlled by an external actuator 256. In operation, the actuator 256 moves the rod 255 axially. An arm 254 connects the rod 255 to a bearing 253. The subsequent motion of the rod 255 and arm 254 combination causes the bearing 253 to move axially. The bearing 253 then drives the control rod 259 axially. The internal shaft is rigidly attached to pin 260, which acts on the helical grooves 262 in the rotation shell 252, illustrated more clearly in Figure 13, to cause it to rotate. The direction of rotation, clockwise or counterclockwise, depends on the direction that the control rod 259 moves in. The rotation shell 252 acts on or otherwise engages the lower shroud 205, and, indirectly, the entire impeller sub-assembly, causing the sub-assembly to rotate. The pitch plate 206, which is rigidly attached to the rotating shaft 210, acts on the pitch control tabs 212 of the vanes 202 to change the pitch of the vanes 202. In operation, an external electronic controller can be used to determine the vane 202 pitch angle for a given pump speed and engine temperature.

Having now fully described the invention, any changes can be made by one of ordinary skill in the art without departing from the scope of the invention as set forth herein. For example, the pitch plate or vanes can also be driven by an electronic or hydraulic actuator. Further, the pitch plate could be replaced by a set of linkages.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed is:

1. A variable capacity coolant pump comprising:

a pump housing for directing the flow of fluid through said pump between an inlet and an outlet;

a shaft rotatably journaled to said pump housing;

an impeller coupled to said pump housing for pumping fluid through said pump housing from said inlet to said outlet, said impeller rotatably journaled to said shaft and including a shroud and at least one vane pivotally coupled to said shroud for pivotal movement between a plurality of pitch angles relative to said shaft;

a pitch plate operatively coupled to said vane for controlling said pitch angle of said vane; and

a spring coupled to said pitch plate for biasing said vane to a maximum pitch angle, wherein said vane varies in said pitch in response to a force of fluid pressure from said inlet and automatically reduces said pitch angle of said vane upon an increase in said fluid pressure from said inlet to reduce the flow of fluid to said outlet.

2. A variable capacity coolant pump as set forth in claim 1 wherein said impeller includes an upper shroud and a lower shroud spaced below and generally parallel to said upper shroud, said at least one vane pivotally coupled between said upper and lower shrouds.

3. A variable capacity coolant pump as set forth in claim 2 wherein said impeller includes a plurality of vanes each pivotally coupled between said upper and lower shrouds by a rivet.

4. A variable capacity coolant pump as set forth in claim 3 wherein each of said vanes extends between opposite first and second ends, said first ends pivotally coupled between said upper and lower shrouds by said rivets.

5. A variable capacity coolant pump as set forth in claim 4 wherein said second

ends of said vanes includes a pitch control tab extending outwardly therefrom and said pitch plate includes a plurality of slots for slidably receiving said respective pitch control tabs of said vanes to guide and limit the pivotal movement of said vanes between said pitch angles.

6. A variable capacity coolant pump as set forth in claim 5 wherein each of said upper and lower shrouds include arcuate shaped slots for slidably receiving and guiding said pitch control tabs therein during said pivotal movement between said pitch angles.

7. A variable capacity coolant pump as set forth in claim 6 wherein said slots in said upper and lower shrouds at least partially axially intersect with said slots in said pitch plate.

8. A variable capacity coolant pump as set forth in claim 7 wherein said pitch plate includes a generally planar disc-shaped plate fixedly secured to said rotatable shaft.

9. A variable capacity coolant pump as set forth in claim 8 wherein said spring includes a torsion spring connected between said rotatable shaft and one of said shrouds for biasing said vanes to said maximum pitch angle defined as being generally transverse to said rotational axis of said shaft.

10. A variable capacity coolant pump as set forth in claim 9 wherein said spring is a coil spring coupled to said shaft and axially displacing said pitch plate into engagement with said shroud for pivoting said vanes and controlling said pitch angle of said vanes in response to rotation of said shaft.

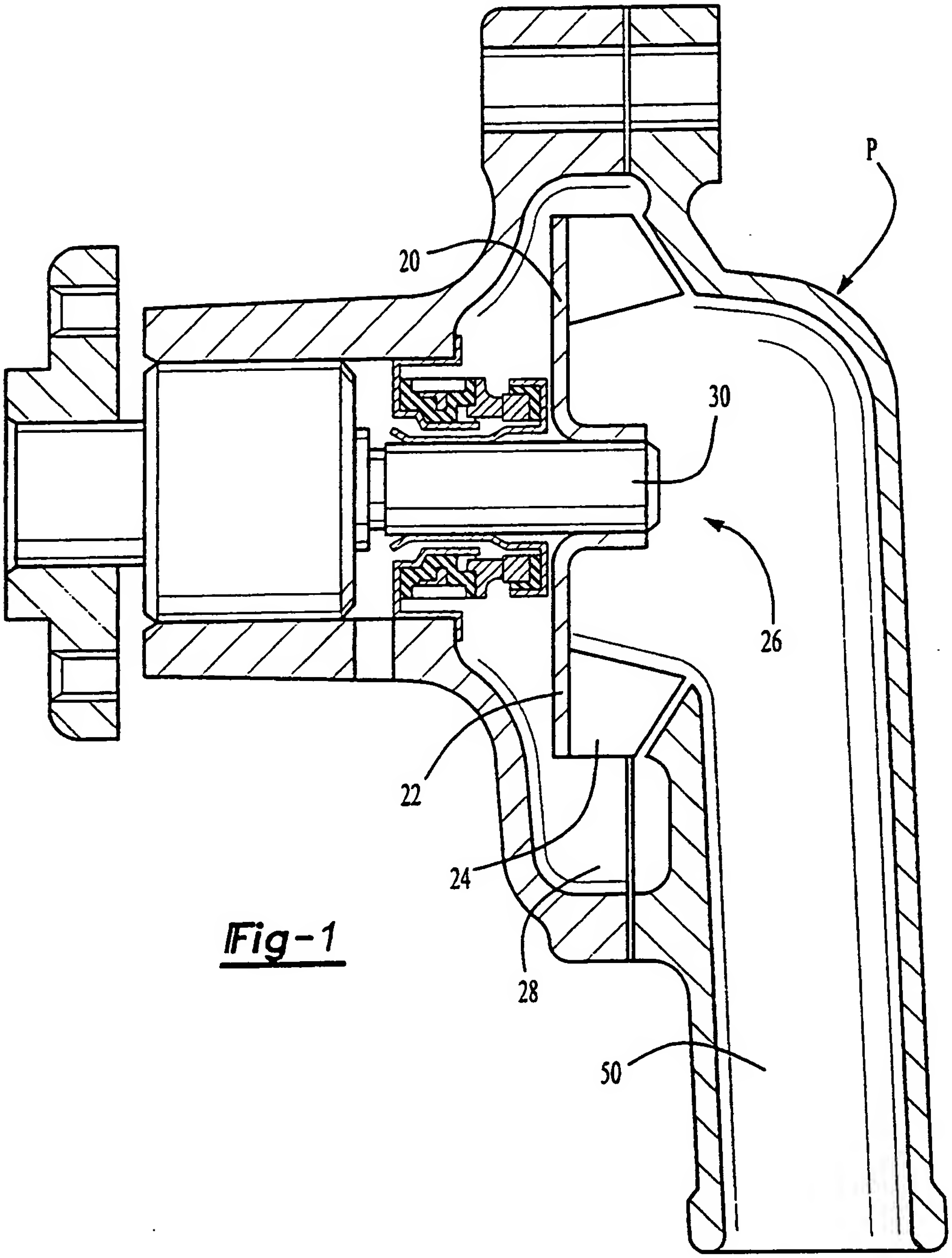

Fig-1

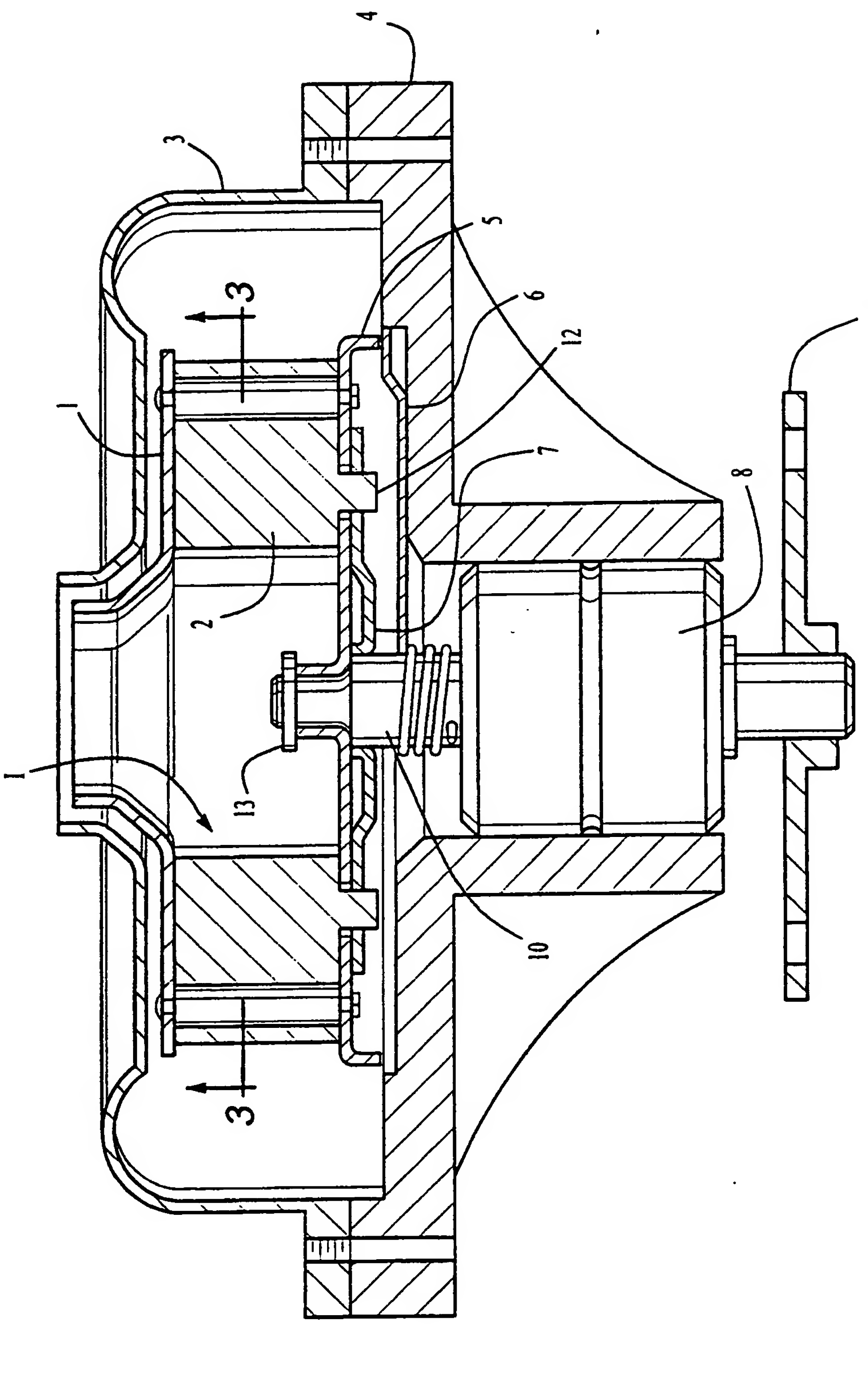

Fig-2

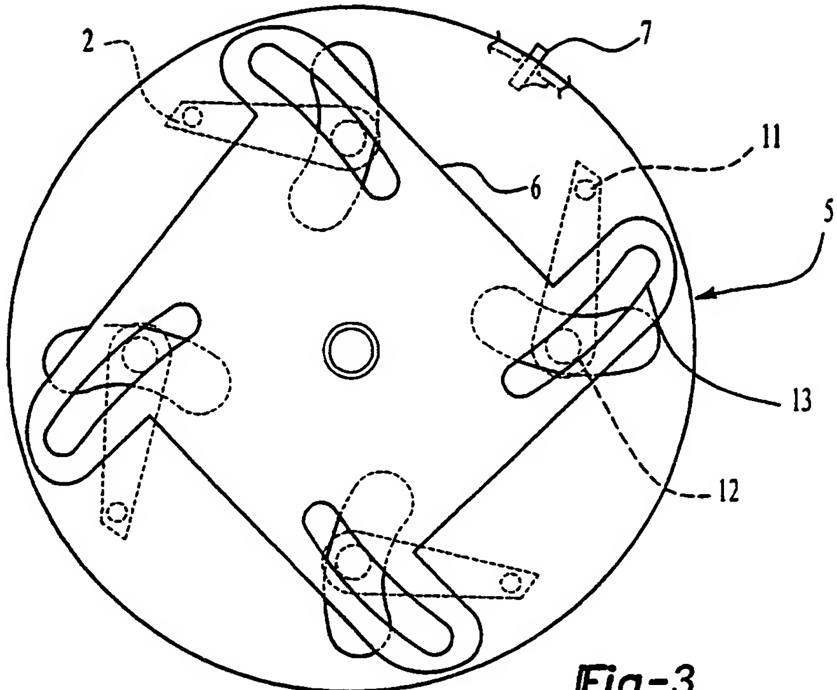

Fig-3

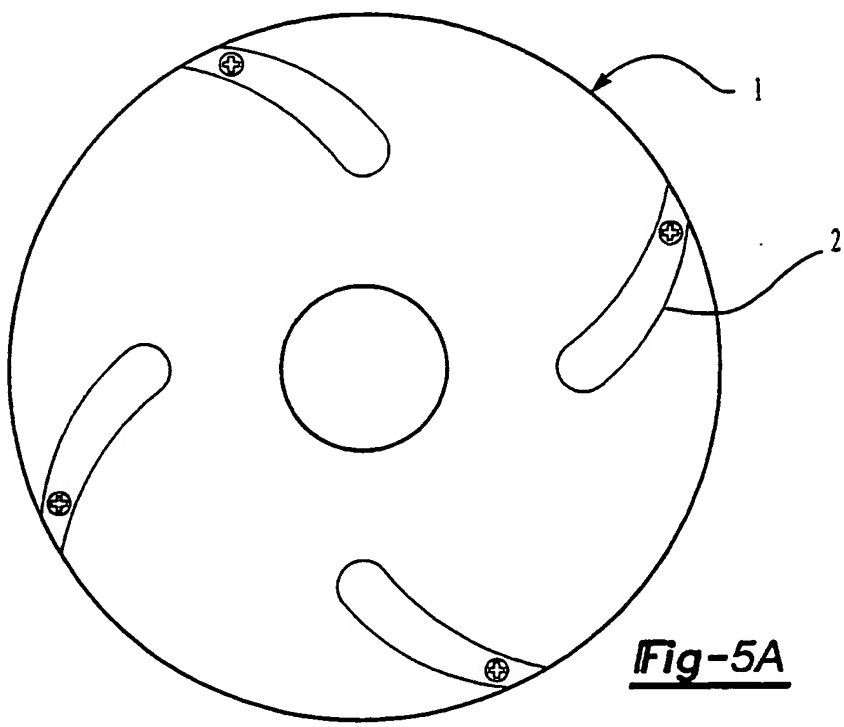

Fig-5A

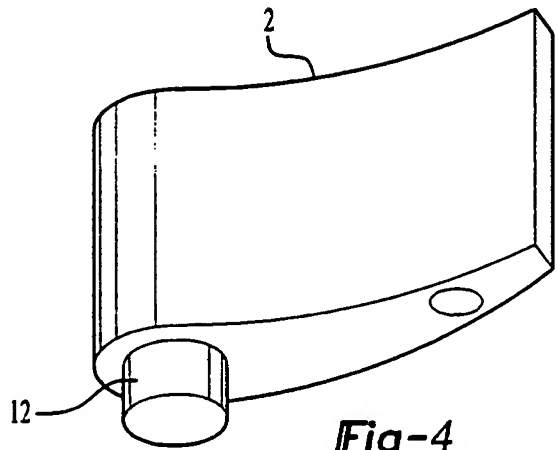

Fig-4

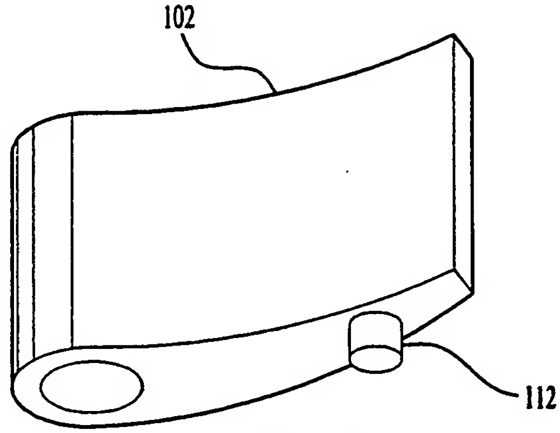

Fig-8

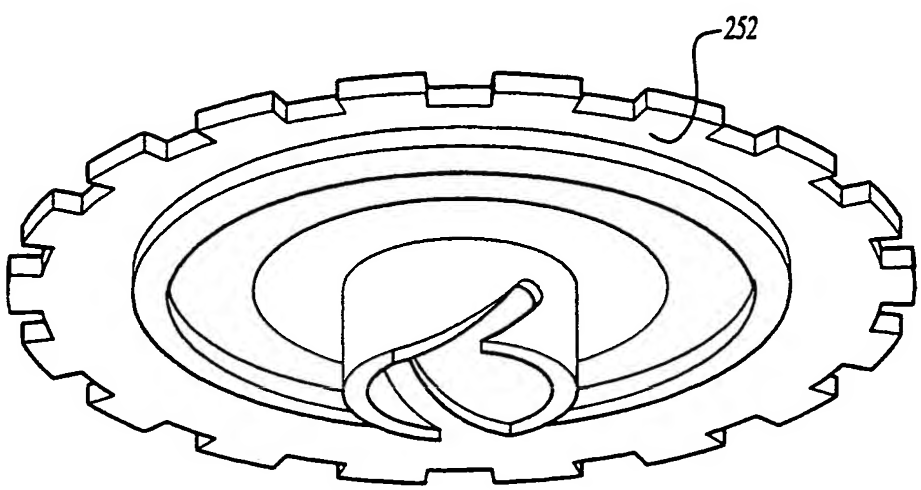

Fig-13

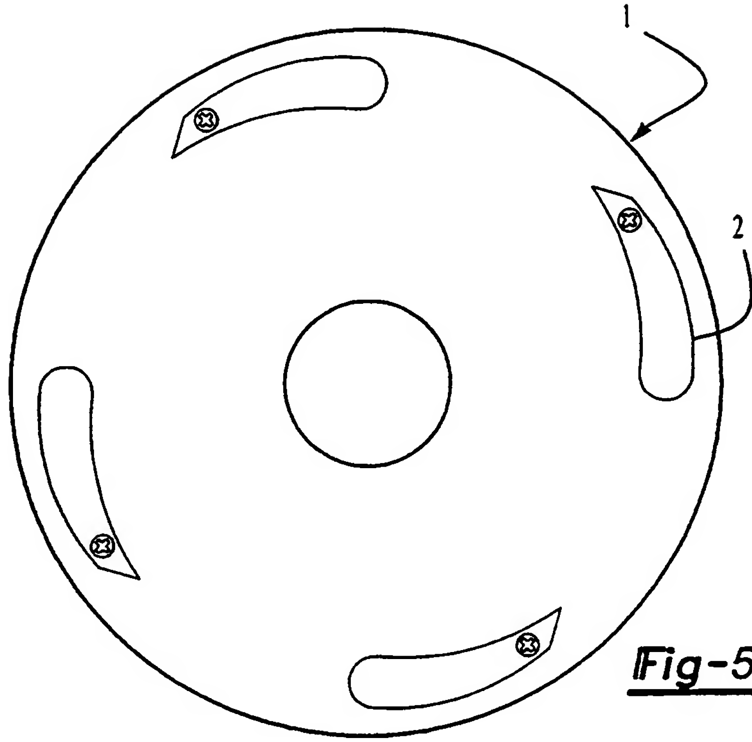

Fig-5B

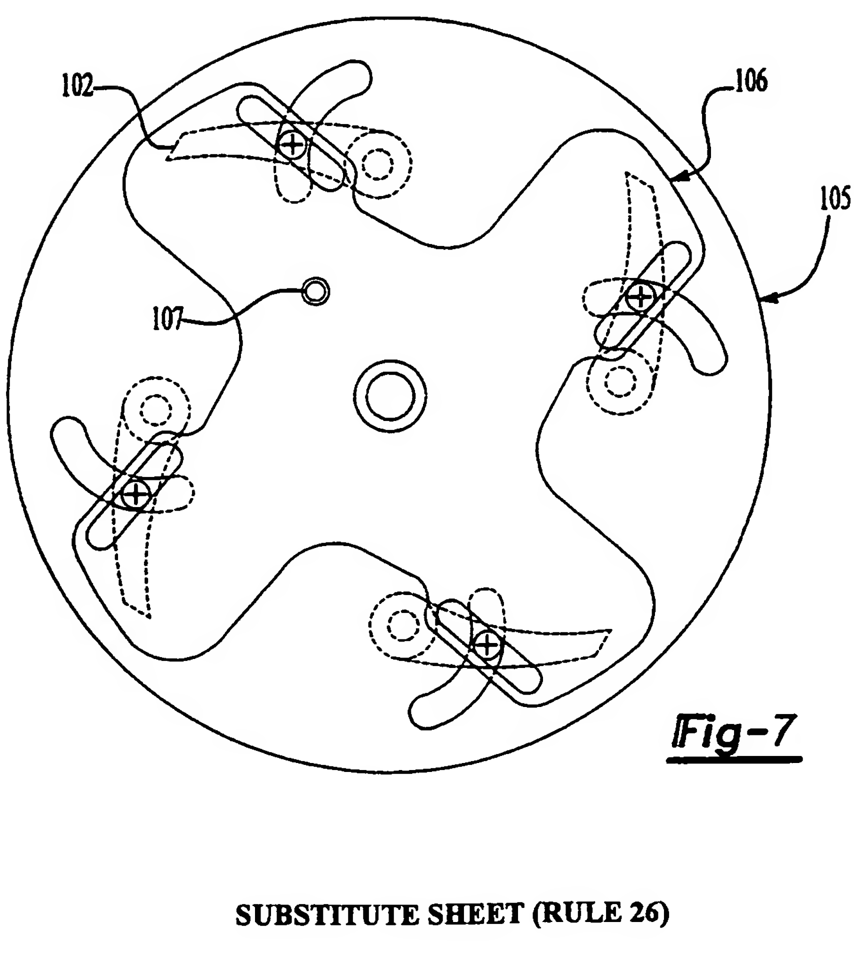

Fig-7

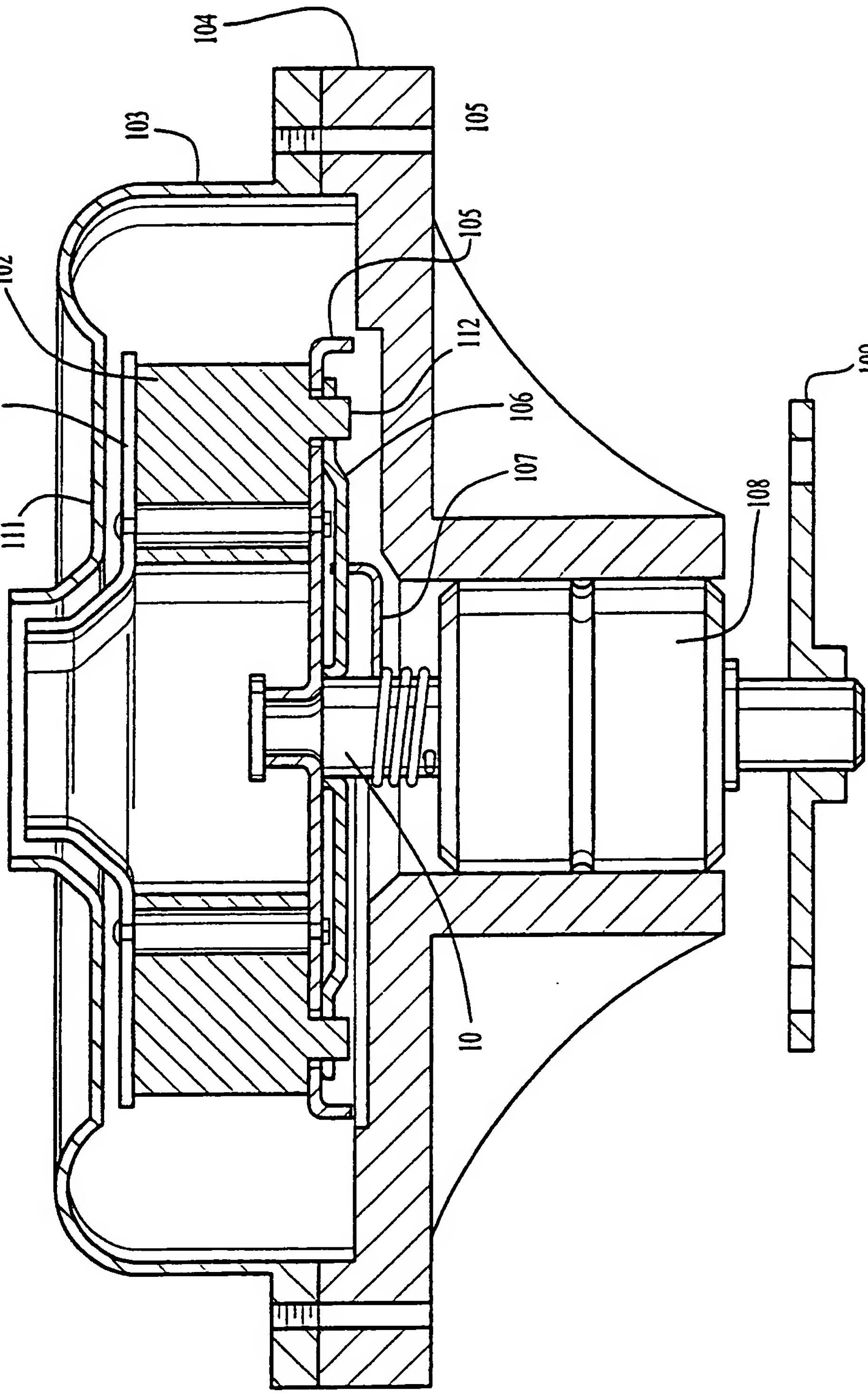

Fig-6

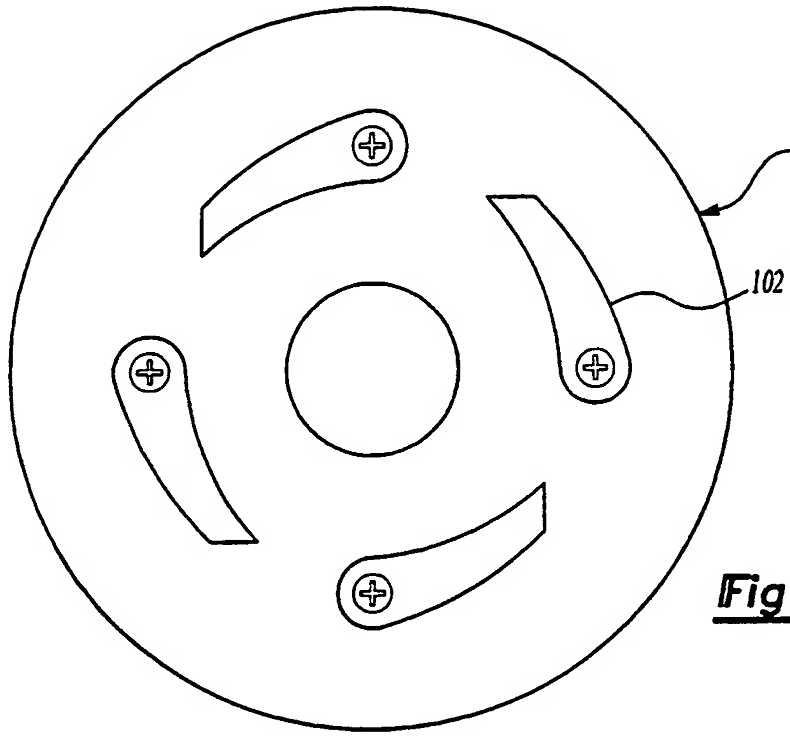

Fig-9A

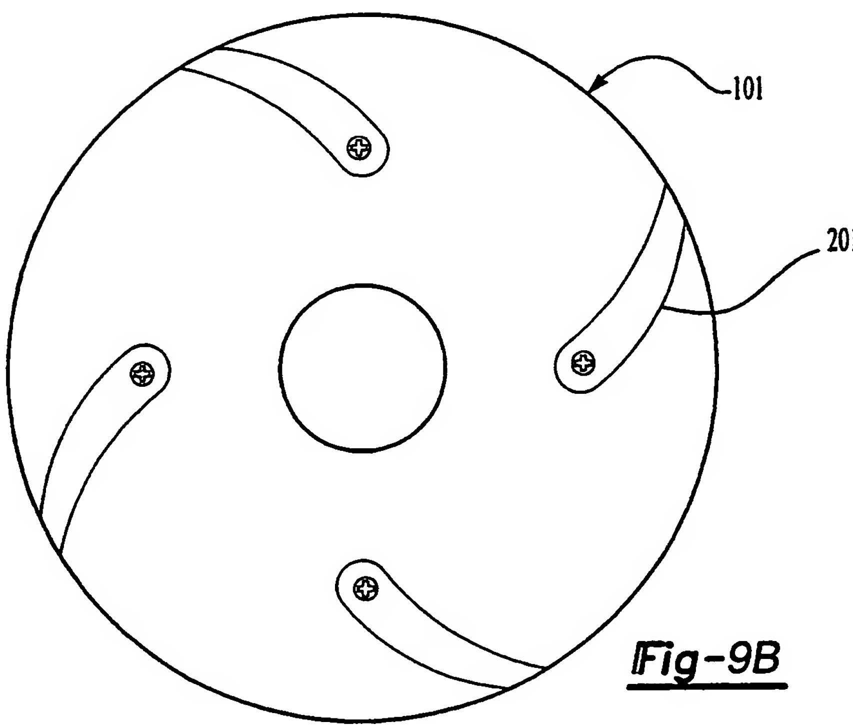

Fig-9B

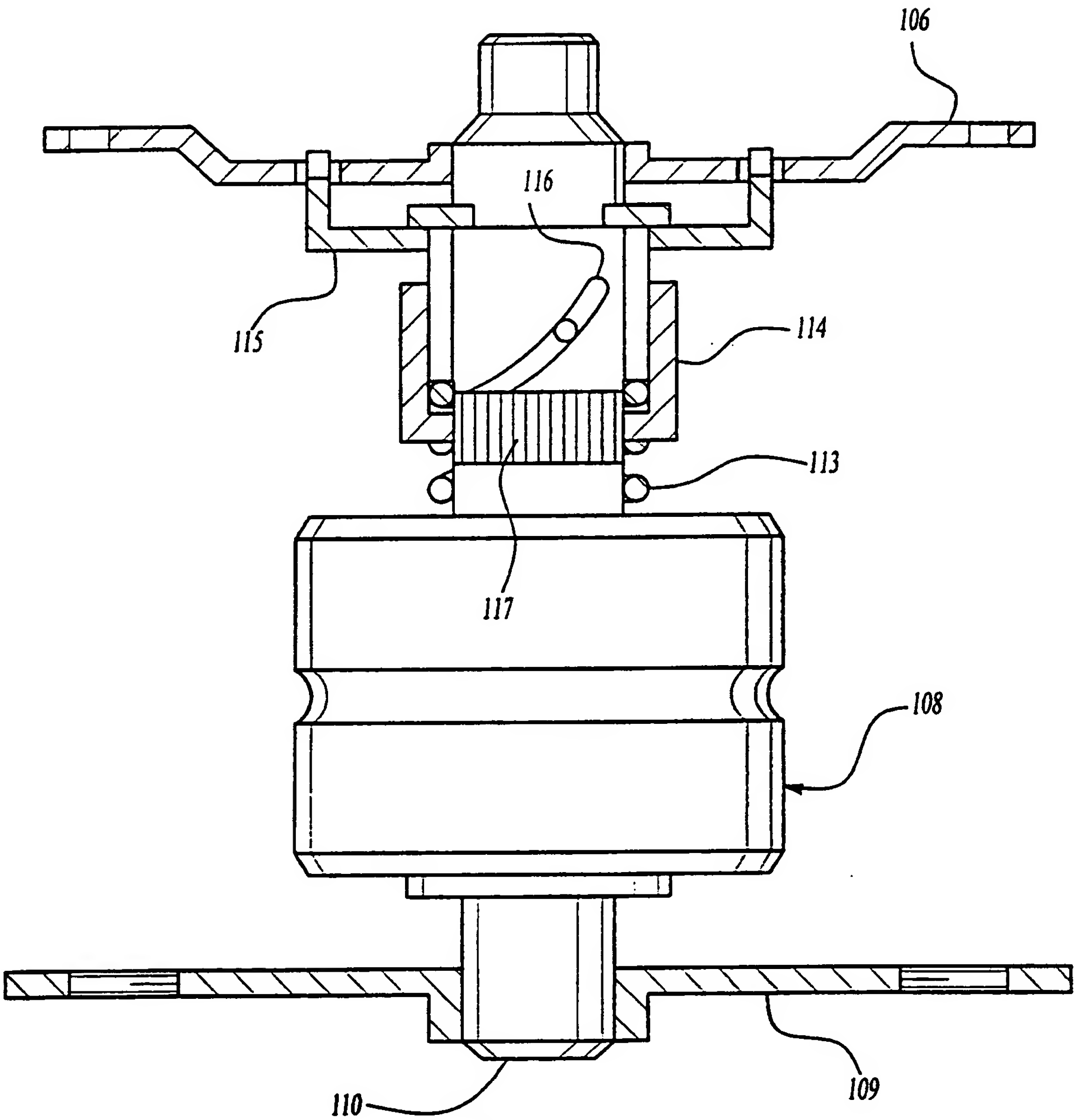

Fig-10

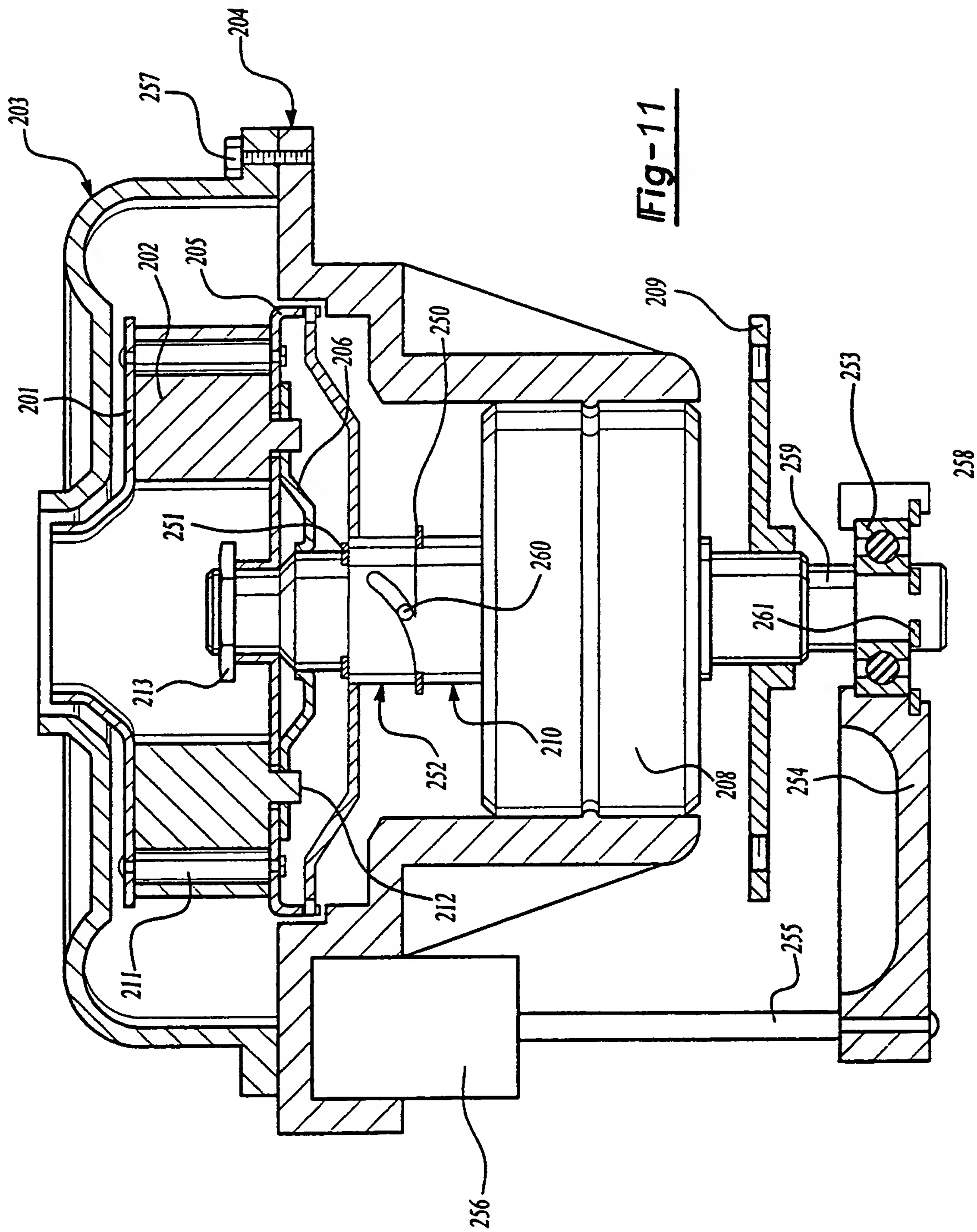
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Fig-11

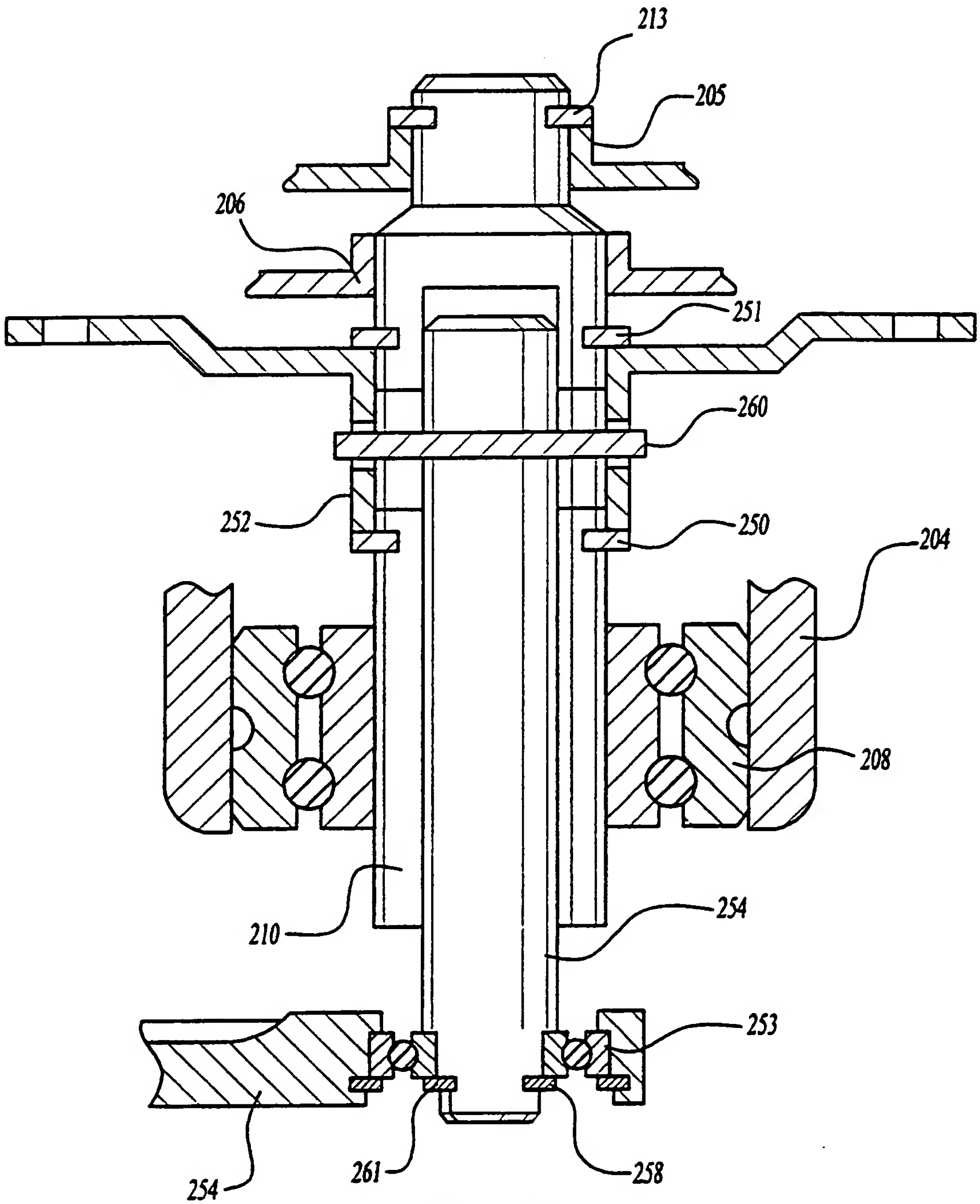

Fig-12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 01/00541

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04D15/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F04D F01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 901 623 A (GRENNAN CHARLES W) 26 August 1975 (1975-08-26) the whole document	1
Y	BE 467 868 A (ATELIERS DE CONSTRUCTION CONSTANT DE RAEDT) 31 October 1946 (1946-10-31) page 3, line 15 -page 4, line 14; figures 1,2	1
A	FR 1 512 443 A (ETABLISSEMENTS POMPES GUINARD) 22 April 1968 (1968-04-22) page 2, column 1, line 13 -page 3, column 2, line 8; figures 1-12	1
A	US 2 950 686 A (LEDEL A.L. & AL) 30 August 1960 (1960-08-30) the whole document	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2001	21/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ingelbrecht, P

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International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 175 393 A (LUCAS AEROSPACE LTD) 19 October 1973 (1973-10-19) the whole document	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 01/00541

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